Is "Processed" a Four-Letter Word? The Role of Processed Foods in Achieving Dietary Guidelines and Nutrient Recommendations[1–3]

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ABSTRACT

This paper, based on the symposium "Is 'Processed' a Four-Letter Word? The Role of Processed Foods in Achieving Dietary Guidelines and Nutrient Recommendations in the U.S." describes ongoing efforts and challenges at the nutrition–food science interface and public health; addresses misinformation about processed foods by showing that processed fruits and vegetables made important dietary contributions (e.g., fiber, folate, potassium, vitamins A and C) to nutrient intake among NHANES 2003–2006 participants, that major sources of vitamins (except vitamin K) were provided by enrichment and fortification and that enrichment and fortification helped decrease the percentage of the population below the Estimated Average Requirement for vitamin A, thiamin, folate, and iron; describes how negative consumer perceptions and consumer confusion about processed foods led to the development of science-based information on food processing and technology that aligns with health objectives; and examines challenges and opportunities faced by food scientists who must balance consumer preferences, federal regulations, and issues surrounding food safety, cost, unintended consequences, and sustainability when developing healthful foods that align with dietary guidelines. *Adv. Nutr. 3: 536–548, 2012.*

Introduction

When the 2010 Dietary Guidelines for Americans (DG)[9] publication was released, 74% of men and 64% of women were overweight or obese, and nearly 15% of American households were food insecure (1–3). The DG focuses on increasing consumption of nutrient-dense foods (e.g., vegetables and fruits, whole grains, low-fat/fat-free dairy products, lean meats, and seafood), and supports limiting consumption of less healthful foods and ingredients (e.g., sodium, solid fats, added sugars, refined grains, and alcohol) (1). Eating patterns, including USDA Food Patterns (and their vegetarian adaptations) (4), and the Dietary Approaches to Stop Hypertension Eating Plan (5), are recommended to promote health, help decrease the risk of chronic disease, and prevent food-borne illness (1).

Current science-based recommendations have not changed significantly over the past 30 y (6). Despite consistent messaging and Americans' self-described familiarity with the DG, the majority of Americans have failed to meet recommendations for all of the nutrient-rich food groups except total grains, meat, and beans (7,8). The DG recommends that nutrient needs be met primarily through consuming foods, not supplements (1). Thus, successful dietary change may require reformulation of existing food products and/or creation of new

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[9] Abbreviations used: DG, Dietary Guidelines for Americans; DRI, dietary recommended intake; EAR, estimated average requirement; E+F, enrichment and fortification; F+V, fruits and vegetables; IFIC, International Food Information Council.

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Table 1. Definitions of processed and minimally processed foods[1]

Term	Definition
Processed food	Any food other than a raw agricultural commodity, including any raw agricultural commodity that has been subject to washing, cleaning, milling, cutting, chopping, heating, pasteurizing, blanching, cooking, canning, freezing, curing, dehydrating, mixing, packaging, or other procedures that alter the food from its natural state. Processing also may include the addition of other ingredients to the food, such as preservatives, flavors, nutrients, and other food additives or substances approved for use in food products, such as salt, sugars and fats. Processing of foods, including the addition of ingredients, may reduce, increase, or leave unaffected the nutritional characteristics of raw agricultural commodities.
Minimally processed food	A food that is processed, but retains most of its inherent physical, chemical, sensory and nutritional properties. Many minimally processed foods are as nutritious as the food in its unprocessed form.

[1] Adapted from Reference 10 with permission.

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food products to help balance consumer choice within the context of taste, convenience, cost, and dietary recommendations (8). Meeting this challenge will require collaboration between nutrition and food scientists—groups whose interactions have traditionally been limited in part because their perception of food differs (9). Nutrition scientists look at foods' nutrient profiles and health properties, whereas food scientists look at foods' hedonic properties (e.g., taste, texture, and sensory appeal) (9).

Ensuring that nutrient needs are met primarily through foods will also require motivating consumers to eat more healthfully. This task requires addressing confusion, misinformation, and negative perceptions of processed foods (8,9). Many consumers do not realize that almost all foods currently consumed are processed (9) (**Tables 1 and 2**) (10,11) and that food processing has historically provided and will continue to provide a safe and abundant food supply that provides significant public health benefit (9) (**Table 3**). The mischaracterization of processed foods and food technology as unnatural, unsafe, and/or nutritionally inappropriate by some health professionals, advocacy organizations, and the media (12) further makes the task of motivating consumers to eat more healthfully challenging.

Finally, the food environment provides myriad choices, from locally grown organic produce to ready-to-eat prepackaged convenience foods. With so many conflicting messages, competing concerns, and food choices, consumers need help making healthful food choices while meeting demands for taste, convenience, and cost. Provision of nutrition information alone is ineffective (7,8). More influential communication strategies coupled with modifications of food and the food environment are needed (8,13–15).

Table 2. The continuum of processed foods[1]

Type of Food	Examples
Foods that require little processing or production (also called minimally processed)	Washed and packaged fruits and vegetables Bagged salads Roasted and ground nuts Coffee beans
Foods processed to help preserve and enhance nutrients and freshness of foods at their peak	Canned tuna, beans, and tomatoes Frozen fruits and vegetables Pureed and jarred baby foods
Foods that combine ingredients such as sweeteners, oils, flavors, colors, and preservatives to improve safety and taste and/or visual appeal (does not include ready-to-eat foods listed below)	Packaged foods (e.g., instant potato mix and cake mix) Jarred tomato sauce Spice mixes Dressings and sauces Gelatin
Ready-to-eat foods needing minimal or no preparation	Breakfast cereal and flavored oatmeal Granola bars, crackers, and cookies Jams and jellies Nut butters Ice cream and yogurt Garlic bread Fruit chews Rotisserie chicken, honey-baked ham, and luncheon meats Cheese spreads Fruit drinks and carbonated beverages
Foods packaged to stay fresh and save time	Prepared deli foods Frozen meals, frozen entrees, and pot pies

[1] Adapted from Reference 11 with permission.

Table 3. Benefits of the modern food system[1]

Benefit	Example(s)
Lower postharvest food losses	Food processing techniques such as milling, grinding, canning, preserving, freezing, drying and packaging prevents food loss due to rodents, insects, and microbial spoilage
Safety	Pasteurization reduces microbial pathogens
	Packaging reduces risk of contamination
	Plant breeding results in reduction of naturally occurring toxicants
Preservation and availability	Modified atmosphere packaging of apples and other fruit leads to extended freshness
Health and wellness, improved nutritional status	Fortification of orange juice with calcium provides key mineral for bone health
	Enrichment of flour with B vitamins decreases risk of nutrient deficiency diseases
	Processing of tomatoes increases bioavailability of lycopene
Convenience	Processing allows for snack foods and beverages that require limited preparation and frozen entrees to be delivered in a form ready for microwave heating
Choice	Gluten-free and lactose-free foods provide more choice for consumers with celiac disease and lactose intolerance, respectively
Quality	Blanching and freezing of vegetables immediately after harvesting ensures peak nutritional values
	Processing of soybeans improves their flavor

[1] Adapted from Reference 9 with permission.

Within this context, this article first examines ongoing efforts and challenges at the nutrition–food science interface and public health. Second, it addresses misinformation about processed foods by describing the contribution of processed fruits and vegetables to nutrient intake among NHANES 2003–2006 participants, and the role of enrichment and fortification (E+F) of the food supply in helping Americans meet nutrient requirements. Next, it describes how consumer confusion and misinformation and negative consumer perceptions of processed foods led to the development of science-based nutrition education materials about processed foods (16). The article concludes with a discussion of challenges and opportunities associated with DG implementation considering the complexities and popularity of processed foods, and the realities of our current food system.

Efforts and challenges at the nutrition–food science interface and public health

Food, the common ground between nutrition and food scientists, should be enjoyed. At the same time, food and nutrition scientists are being challenged to create highly palatable, reasonably priced foods that meet public health nutrition needs. For example, within the context of achieving and maintaining a healthy weight, the DG recommends that Americans consume more nutrient-dense foods and fewer energy-dense foods with less healthful ingredients (such as solid fats, added sugars and sodium) (1). Scientists are thus being challenged to balance problem ingredients with helpful ingredients without sacrificing palatability and affordability.

Historically, many combinations of ordinary foods, such as the USDA Food Patterns and the Dietary Approaches to Stop Hypertension Diet Eating Plan (4,5) provided substantial health benefits. Another eating pattern known as the dietary portfolio, a low, saturated-fat diet that contained sterols, soy protein, and viscous fiber, was reported to be as effective as some statins at reducing LDL cholesterol (17). Despite benefits, this healthful portfolio diet was not very popular. People do not necessarily follow dietary advice, and consumers are fickle about "better for you foods" (7,18). Even the favorable lower fat nutritional profile of the McLean Deluxe burger years ago could not overcome its tough and dry taste when cooked incorrectly, illustrating that taste and functionality problems still trump nutrition (19–21).

The "lone ranger" approach of the past, when food and nutrition scientists worked alone and sprang surprises on each other is an outdated paradigm. Today, scientists are being called on to work together with health and medical professionals to practice nutrition engineering to create products and packages that help consumers meet dietary recommendations and that help solve current pressing health issues. To date, collaborations have resulted in the reduction of salt and energy in processed foods (22,23) (although it can take a year or more to ensure that low-sodium processed meats and cheeses meet food-safety standards, and it takes time for consumer preferences to change as well), reformulated food products with reduced amounts of *trans*-fatty acids (24,25), smaller portion packages (26), and front-of-package nutrition labeling (27). [See **Table 4** (27–55) for additional examples of nutrition engineering collaborations.]

Despite advances, challenges must be addressed, and scientists must learn from past mistakes. For example, food scientists have developed more convenient, affordable, tasty, and nutritious foods that meet dietary recommendations, but they have done so by relying on food processing and novel ingredients, which may provoke consumer objections. Sometimes, these objections have scientific merit [e.g., consumers have every right to be concerned if ingredients lack a history and consensus of safe use (56), if novel, never tested products such as probiotics with new strains of organisms or unstandardized soy isoflavone supplements are used (57,58), or if folic acid use exceeds its upper limit (59)]. Other times, consumer objections may lack scientific merit, but they are still a legitimate expression of their right to choose (even if their reasons are those that scientists may not agree with).

Fears of strange and frightening new food technologies can lead to the avoidance of foods regarded by food and nutrition scientists as safe and healthful, such as Quorn (fungal meat substitutes popular in Europe) (60,61) and irradiated

TABLE 4. Examples of nutrition engineering collaborations

Food product, ingredient, or technology	Potential benefit or application
Oils from soybean cultivar (28,29)	Reduced saturated fatty acids and higher (n-3) fatty acids (stearidonic acid)
"Super broccoli" cultivar (30)	High in isothiocyanate sulforaphane
Resistant starches and fibers (31–34)	Weight management, satiety
Glucan (35,36)	Partial salt replacement in meat
Oligosaccharide prebiotics in yogurt (37)	Stimulate growth of healthful bacteria in the gastrointestinal tract
Lactobacillus acidophilus probiotics in yogurt (38–40)	Addition of healthful bacteria to gastrointestinal tract
Whole grain–rich foods; foods enhanced with bran fractions (41,42)	Weight loss, satiety, cholesterol lowering
Grains biofortified with zinc and β-carotene (43,44)	Improved nutriture of individuals in underdeveloped countries
Low-gluten foods (45)	Increased choices for patients with celiac disease
Foods without allergens or with allergens labeled (46,47)	Increased choices for patients with allergies
Fats that help with cell signaling and satiety (48)	Energy metabolism control
Low-sodium soy product tempeh and meatless entrees (49,50)	Low-cost nutritious food for vegetarians and children participating in National School Lunch Program
Nanoparticles and enzyme technology (51–53)	Enhanced bioavailability of lycopene and phenolics
Removal of aflatoxins and fumonisins (54,55)	Improved food safety

fruits, vegetables, and meats (62,63). Consumers may object to processing and novel ingredients based on aesthetic reasons or both aesthetic and nonscientific reasons. Consumers want food processors to develop better tasting salt and sugar substitutes that deliver the same desirable hedonistic qualities of taste, texture, and mouth feel. At the same time, consumers fail to realize that when food processors develop salt substitutes, they must also consider the antibacterial and stability functional qualities of sodium chloride (64), and when processors develop sugar substitutes, they must also consider consumers' fears of developing a sweet-tooth habit (65,66). Philosophical reasons, such as belief in whole foods, dislike of food scientists tinkering with or intruding on traditional foods and diets, and a belief that processed foods, fortified foods, and bioengineered ingredients are unnatural can lead to consumer objections to processing and use of non-naturally occurring ingredients. Finally, economic reasons, such as price in the marketplace, or the true cost of food (considering its carbon footprint) can cause consumer objection (21).

Another challenge at the nutrition-food science interface is how to define nutritious foods. Should a dichotomous good food/bad food system, a green-yellow-red "go-slow-whoa" traffic-light system, or a nutrient continuum be used (67–69)? What is the best way to determine how many discretionary features (e.g., taste, visual appeal, convenience, extended shelf life) consumers want and/or need in their food? In addition to considering these discretionary features, some consumers also consider the nutritional value, health benefit(s), safety, and/or origin of the food they are purchasing (21,70). Others believe that ultraprocessing results in foods that are no longer recognizable and that food production that lacks attention to factors such as sustainability, a small carbon footprint, and reasonable cost will ultimately backfire (71).

Partnerships between nutrition and food scientists are essential. The "ready, fire, aim" mistakes of the past (where nutrition and food scientists fired at each other before aiming at the problem) should be avoided. When food scientists worked in isolation and created low-saturated fat frozen meals, for example, and then nutritionists fired back, criticizing that these meals were high in energy, total fat, sodium, and added sugars, it was not the most helpful way for scientists to interact. Nutritionists who demand immediate action to ban an ingredient based on aesthetics or theoretical risks rather than an evidenced-based approach are not being helpful.

A closer nutrition-food science interface is one key to creating new and more healthful foods; however, such an approach is challenging. Sometimes, but not always, mishaps have resulted from ignorance. For example, food scientists did not realize the problems with low-saturated fat, high-*trans* fatty acid cooking oils; low-saturated fat, high-sodium TV dinners; low-sodium and low-chloride infant formulas (72); and low-sugar, high-energy desserts. Food technologists cannot be blamed for their lack of consideration of sugars and starches unless their content can be measured. (Until recently, carbohydrate content of foods was calculated by difference e.g., total energy minus energy from fat and protein). Other times, mishaps resulted from overly simplistic views. For example, a famous professor boasted in the 1970s that he had not eaten an egg in a year because of his concerns about LDL cholesterol; dietary cholesterol is now known to be only a modest contributor to blood cholesterol. Mishaps also resulted from lack of clarity (e.g., consumers were recommended to reduce total fat consumption, but were not cautioned against consuming less saturated and *trans* fatty acids). Additionally, mishaps resulted from overemphasizing single nutrients, such as β-carotene, vitamin A, and fiber. Finally, mishaps resulted from overemphasizing positive traits, without providing consumers information about what is realistic, clinically meaningful, or cost-effective (e.g., the promotion of only positive trials conducted on pomegranate juice; the promotion of health benefits of (n-3) eggs, without considering total egg consumption and higher cost; the promotion of benefits of resveratrol from wine, even though it is impossible to get an effective dose with reasonable wine consumption; and vague statements about whole grains on food labels when it is not made clear how much whole grain is actually in these products.)

In the future, nutrition and food scientists can be more productive than they have been in the past, and they can work together to create new foods for healthful eating through a closer nutrition-food science interface (**Table 5**). Nutritionists and food scientists must continue to collaborate to provide pragmatic, food-based solutions to public health problems and to help consumers comply with dietary recommendations while eliminating food-based barriers of taste, convenience, and cost.

The contribution of processed fruits and vegetables to nutrient intake

To better understand the contribution of fresh and processed fruits and vegetables (F+V) to energy and nutrient intakes among Americans, NHANES 2003–2006 dietary records of Americans aged 2 y and older (73) were examined. F+V were specifically chosen because they provide important dietary shortfall nutrients (vitamins A, C, and E, folate, potassium, and dietary fiber), and, as low-energy dense foods, they are recommended as part of diets to manage body weight (1).

The final sample (N = 16,822) comprised all subjects aged 2 y and older with a complete first-day 24-h dietary recall interview. Energy and nutrient intakes were determined for 5 categories of F+V: total F+V (all fresh and processed F+V, including juice), fresh F+V, and frozen, canned, and dried F+V (which comprised the processed category) (74–79). Results indicated that dried F+V provided insignificant contributions to Americans' diets. Fresh, canned and frozen F+V provided 73% of vitamin C, 36% of fiber, 31% of potassium, 24% of vitamin A, 18% of total sugars (of which <2% were added sugars), 9% of sodium, and <10% of daily energy to the diet. The contribution of individual categories of F+V to daily energy and nutrient intakes is illustrated in **Figure 1**. Fresh F+V contributed significant amounts of vitamin A, fiber, and folate (75%, 65%, and 60%, respectively), whereas processed F+V contributed significant amounts of vitamins E and C and potassium (62%, 51%, and 47%, respectively). Processed F+V contributed more than half (57%; 119 kcal) of the energy provided by all F+V, and more than half (59%; 14 g) of the total sugars provided by all F+V. Although 83% of added sugars in F+V came from canned F+V, this proportion amounted to a very small fraction (1.2%) of added sugar intake. Processed F+V contributed more than two thirds (69%; 219 mg) of sodium provided by F+V; the majority (78%) of sodium came from canned F+V. Overall, processed F+V provided 7.2% (170 mg) of daily sodium intake. In summary, processed F+V provided significant amounts of shortfall nutrients (35% of fiber, 40% of folate, and 47% of potassium) and significant amounts of vitamins A and C (25% and 51%, respectively) in Americans' diets. Consumption of processed F+V supports eating plans described in the DG (1).

Table 5. Key recommendations for successful collaborations between food and nutrition scientists

1. Work together from the start rather than taking the "ready, fire, aim" approach
2. Agree on distinctions between science, aesthetics, and philosophy
3. Use clearer definitions for food processing to avoid consumer confusion
4. Create sensible goals and means to reach these goals
5. Set priorities because scientists cannot do everything
6. Learn to disagree without being disagreeable
7. Treat food views like others' religious views—with respect, even if they disagree with yours

The role of enrichment and fortification on nutrient intakes

To examine the contribution of E+F on nutrient intakes, an almost identical NHANES sample (N = 16,110) to that previously described was used [the only difference was that pregnant and lactating women, whose dietary reference intakes (DRI) are different, were excluded.] USDA databases (74–79) were used to determine when and which foods were fortified and/or enriched. This approach enabled separation of naturally occurring nutrients from those added through enrichment and/or fortification. Nutrient intakes from dietary supplements were also determined. The National Cancer Institute method (80) was used to estimate usual intake of naturally occurring nutrients, naturally occurring nutrients plus nutrients added to enriched or fortified foods, and total nutrients from foods plus dietary supplements. The most current DRIs for 19 nutrients (including the most recent DRIs for vitamin D and calcium) were used (81–85). Reported results focused on the percentage of the population below the estimated average requirement (EAR) using the cut-point approach (except for iron). All DRI age-sex groups were evaluated, with data presented for children aged 2 to 18 y and adults aged 19 y and older.

On the day of the recall, >50% of the vitamin D in children's diets came from fortified foods; these foods also provided between 12% and 20% of vitamins A, C, B-6, and B-12. Although fortified foods provided ∼30% of vitamin D to adults' diets, such foods provided much lower amounts of vitamins A, C, B-6, and B-12. Fortified foods provided almost no vitamins E or K to diets of children or adults. Examination of the contribution of enriched and fortified foods to thiamin, riboflavin, niacin, folate, and iron intakes showed that in all cases, the contribution of these foods was greater in children compared with adults and that the 3 enriched nutrients (thiamin, riboflavin, and niacin) found in bread and many cereals made similar contributions to children's diets. Folate E+F contributed >30% of folate to the diets of children and adults, whereas iron E+F made slightly lower but still important contributions. In adults, compared with children, supplements provided a larger portion of the daily vitamin intake. Supplements were the primary sources of vitamins C, E, B-6, and B-12 and thiamin and riboflavin in adults. In both children and adults, almost all minerals came from naturally occurring sources (86).

The percentages of children and adults with total usual nutrient intake whose dietary intakes would fall below the

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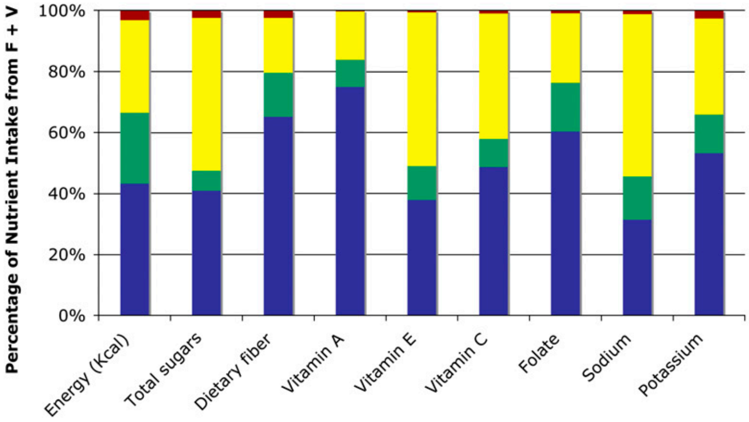

Figure 1. Contribution of fresh, frozen, canned, and dried fruits and vegetables to daily nutrient intake.

EAR for all reported nutrients considering that naturally occurring, enriched, and fortified sources were examined (**Fig. 2**). Results indicated that without E+F, 100% of the population would fail to meet the EAR for vitamin D; even with E+F, >90% were still in jeopardy. Without E+F, >75% of the population failed to meet the EAR for vitamin A; with E+F, this decreased significantly to ∼40%. Thus, E+F with vitamin A provided 30% of the population with adequate intakes of this nutrient. Smaller but significant changes were noted for E+F with vitamins C and B-6, but not for vitamin E (which is not typically fortified). For iron, without E+F, 20% of the population would fall below the EAR; this percentage was lowered to ∼ 6% with E+F. The most dramatic effects of E+F were noted for thiamin and folate. For thiamin, without E+F, 50% of the population would have inadequate intakes compared with only 5% with E+F. For folic acid, without mandatory (and some discretionary) E+F, almost 90% of Americans would have inadequate intake compared with only 10% with E+F. These results showed E+F played an important role in decreasing the percentage of Americans with inadequate dietary intakes of many vitamins (except vitamin K) and E+F played an important role in decreasing percentages of the population below the EAR for vitamin A, thiamin, folate, and iron. With respect to minerals, even with E+F, >50% of the population had inadequate intakes of Ca and Mg. There were fewer benefits with respect to phosphorus, zinc, copper, and selenium, but intake of these minerals was generally already adequate (86).

Development of science-based nutrition education materials about processed foods

Despite the fact that some foods require processing to be palatable (e.g., grains), safe (e.g., pasteurized milk), or available year round (e.g., canned and frozen fruits and vegetables), activists quoted regularly in the media continue to attack processed foods (87–89). Whether preparing food to feed a family or providing food for 310 million Americans, the fundamentals of food processing [e.g., a sophisticated form of handling, cooking, transforming, preserving, and/or delivering foods (9)] are similar. To help consumers (who lack knowledge of where food comes from) visualize the farm-to-table concept and to provide food, nutrition,

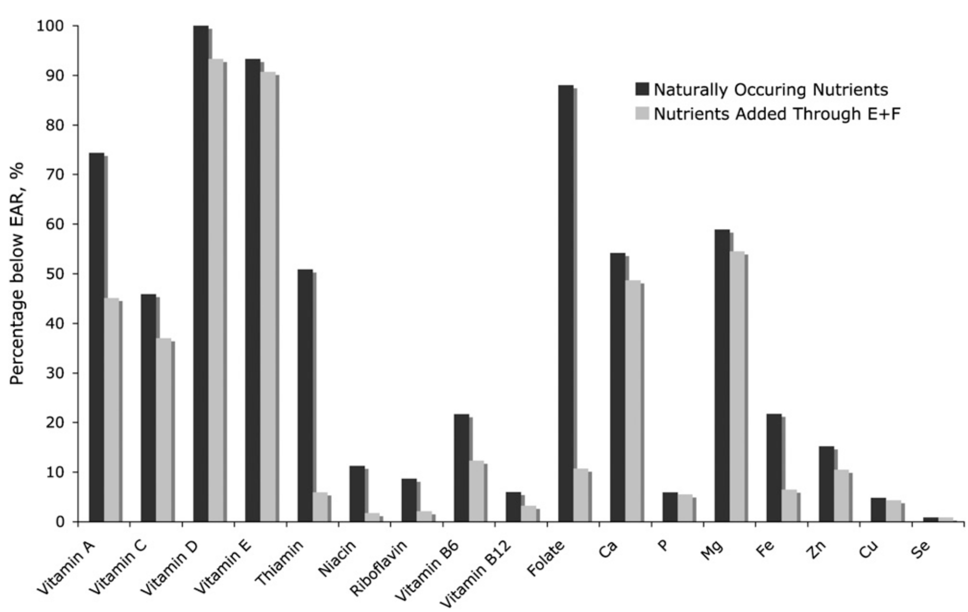

Figure 2. Percentage of the population with vitamin and mineral intakes below the estimated average requirement (EAR) for individuals aged 2 y or older (data from NHANES 2003–22006; *N* = 16,110). E+F, enrichment and fortification. Reproduced from Reference 86 with permission.

and health communicators with science-based information about processed foods, the International Food Information Council (IFIC) and its partners undertook a 4-y research, development, and evaluation process that resulted in the consumer-targeted Understanding Our Food Communications Tool Kit (16).

The process started in 2008 with a systematic analysis of the food environment. This analysis revealed that the mostly negative social, political, and economic conditions toward processed foods were driven in part by the belief that these foods cause obesity, and, secondarily, by the growing local and organic food movements. The analysis also revealed that benefits of processed foods were not being communicated clearly and consistently and that negative messaging about processed foods was appearing in the marketplace. To substantiate these observations and to determine potential positive messaging opportunities, IFIC hired the Artemis Strategy Group (90) who, in December 2008, conducted a follow-up, national online survey among 1500 US primary grocery shoppers or those who shared shopping responsibility in a household. Results confirmed that consumers' perceptions of processed foods were mostly negative and cut across all demographics. The 43% of respondents who rated the term *processed foods* as unfavorable compared with the 18% who rated it favorable were more likely to be white and married, to have children living at home, and to have achieved a higher educational and income status. Those with unfavorable ratings were also self-defined as being knowledgeable about food. The IFIC learned that a relatively small proportion of respondents indicated any recent exposure to media about processed foods, which suggested that negative perceptions and concerns were deeply rooted. This perception and deeply rooted concern may be due in part to consumers misinterpreting health professionals' advice to "eat healthy foods to improve health and weight" as "do not eat processed foods." However, the 40% of respondents who reported "neutral" views toward the term "processed foods" indicated to the IFIC that there were opportunities to provide balanced communication.

Despite unfavorable ratings of the term processed foods, research indicated that 93% and 83% of respondents revealed that they had consumed processed and minimally processed foods, respectively, over the past 6 mo. Consumption of fresh, natural, and organic foods was also reported to be high (98%, 73%, and 62%, respectively) as was consumption of "fast" food and "junk" food (87% and 86%, respectively). To determine whether consumers' attitudes toward processed foods or negatively perceived ingredients highly associated with processed foods (e.g., sodium, *trans* fats and high-fructose corn syrup) would lead to deselection of these foods or ingredients, respondents were asked to indicate whether they were planning on changing (increasing or decreasing) consumption of certain foods or ingredients over the next 6 mo. Consumers reported that they planned to eat more fresh food, whole grains, poultry, natural foods, fruits, vegetables, and 100% juice (**Fig. 3**). Although no specific category of processed foods was projected to be deselected at the same pace as processed foods overall, virtually all items listed fell more or less heavily on the deselection side, with fast food, junk food, processed food, desserts, red meat, and regular soda the most deselected.

Finally, consumers were asked to indicate what traits were most important to them when purchasing foods and beverages. Ninety-five percent of respondents reported taste was extremely important or very important, indicating that as much as people say they want to eat nutritious or healthful foods, they do not consume foods that do not taste good. Ninety percent of consumers indicated freshness, 80% indicated value, 78% indicated safety, and 76% indicated cost as extremely important or very important. Processed foods were rated as having positive attributes of value, consistency, and convenience and were highly associated with safety and cost (which may explain why so many processed foods continue to be purchased despite consumers' guilty feelings about purchasing them.)

Despite strong dichotomies that appeared to emerge about processed foods, quantitative research indicated that there were avenues for positive messaging. Although some consumers perceived the term processed food negatively, IFIC experts believed that the knee-jerk reaction that led to statements like "to be healthy, just avoid processed foods" failed to acknowledge that processed foods are a critical component of Americans' everyday diet and that avoiding processed foods is neither realistic nor necessary. Further, many consumers perceived processed foods as providing good value for their money and associated them with numerous positive attributes. The fact that these and other benefits of processed foods were not being discussed, indicated an opportunity to provide educational materials to consumers about the benefits that most had taken for granted.

Next, a task force comprising academicians from departments of food science, agriculture, applied economics, and communication conducted research on the history, contributions, and controversies surrounding processed foods. The research resulted in the peer-reviewed research paper "Feeding the World Today and Tomorrow: The Importance of Food Science and Technology" (9). This paper provided the basis for the IFIC to conduct more focused consumer communication work over the next year, in partnership with academic advisors and FoodMinds (91).

Development of the Understanding Our Food Communications Tool Kit followed. The tool kit was developed to provide background information and teaching tools (for professionals and leaders in agriculture, food and nutrition, health, and industry who communicate with consumers) to help clear up misperceptions about food production and food processing and to provide facts about the benefits of processed foods and large-scale agriculture. Based on previous research, messages were aimed at the 2 consumer groups most likely to benefit. The first was a large group of primary shoppers identified as being neutral or favorable toward processed foods because this group was known to be cognizant of the unfavorable assumptions about processed foods and thus vulnerable to a vocal court of public opinion. The

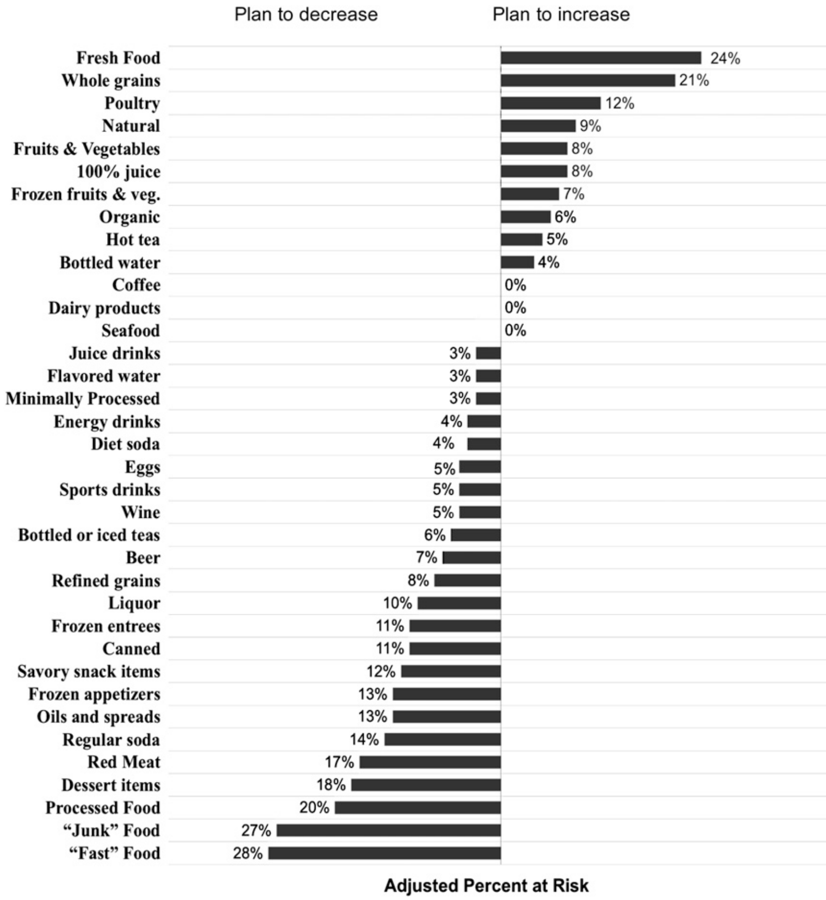

Figure 3. Foods and ingredients consumers plan to increase or decrease over the next 6 mo.

second was a smaller group identified as being somewhat unfavorable to processed foods because their perceptions might change with education. It was also hoped that the tool kit would have broad use and provide information to anyone with questions or concerns about food.

Understanding Our Food Communications Tool Kit was composed of a definitional core (e.g., The Continuum of Processed Foods) (Table 2), which informed consumers that most, if not all, of the foods that they eat, whether at home or in restaurants, are processed or had processed foods as ingredients. The tool kit also provided 4 key messages that focused on benefits of processed foods (**Table 6**). Messages were not meant to "bash" other acceptable food categories, like organic and natural, but rather to provide a realistic view of the food system and illustrate the breadth of marketplace choices allowed for by our large modern agricultural system. Working with Strategic Intent (92) and FoodMinds (91), consumer messages were tested in May 2010 before its final publication.

A national quantitative consumer study was conducted among 644 primary grocery shoppers or those who shared household shopping responsibility to understand consumer reactions to the proposed content and to gauge the level of message interest, importance, and believability. Of the 644 participants, 300 were self-defined as somewhat unfavorable to processed foods, whereas the others were neutral or favorable. A repeated-measures design assessed consumer reactions before and after reading the definitional core and 4 key messages. Results indicated that after content exposure, favorability ratings toward processed foods increased in both groups. A more dramatic increase was seen in the group self-defined as somewhat unfavorable; their favorability rating increased 40% (from 0 to 40%) compared with 19% (from 35% to 53%) in the group self-defined as neutral or favorable.

This quantitative study indicated that Understanding Our Food Communications Tool Kit information was well received and could potentially have a far-reaching impact depending on message dissemination. This research further demonstrated that when the definitional core and 4 key messages were provided together to consumers, perception of processed foods changed dramatically. Consumers remarked that "there is more to processed foods than I thought," "I had no idea processed foods were so prevalent—even in ways one would not think, such as natural or organic," and "this message is relevant because everyone always says processed foods are bad for you when almost everything they (and I) eat is in fact a processed food." This research indicates that science-based nutrition education materials about processed foods are useful in educating consumers, especially those who are somewhat unfavorable toward processed foods. Journalists, educators, and academicians will find on the IFIC Foundation Web site (93) scientific information about processed foods that can be used

Table 6. Key benefits messages associated with processed foods in the Understanding Our Food Communications Tool Kit[1]

Key benefit	Example of message
Safety, taste, high-quality, affordable food	Our food production system today delivers safe, tasty, high-quality, affordable food to your forks.
	Farmers, in partnership with food manufacturers, grocers, and food service establishments, bring an abundance of choices to your family table or restaurant menu, offering a wide spectrum of high-quality flavors and nutrients.
Endless choices of foods and ingredients	Food producers offer endless choices of foods and ingredients to prepare or add to your meals.
	When planning your meals for the day or week, processed foods are among the many options to pick from, depending on your lifestyle, personal preference, and dietary needs.
Time-saving, nutritious products	Food processing makes it possible to have time-saving, nutritious products to help make meal preparation easy for today's busy families.
	With today's busy lifestyles, everyone needs a little help getting a nutritious meal on the table.
	Your grocer can help with fast, affordable, flavorful options, regardless of the size of your family.
Favorite foods available all year long	Modern agriculture makes it possible to enjoy your favorite foods all year long.
	Without the advancement of global food systems, many of your favorite foods would only be available for short periods during the year.
	With modern food production, a variety of your family's favorite foods is available each and every day, no matter where you live.

[1] Adapted from Reference 16 with permission.

to clarify mixed messages and tailor health messages to specific audiences.

Challenges and opportunities associated with implementation of the DG

Implementation of the DG challenges nutrition and food scientists to balance dietary recommendations with consumer preferences, federal regulations, and issues surrounding food safety, cost, unintended consequences, and sustainability. For example, the DG recommends that Americans "consume fewer processed foods that are high in sodium" (1). This recommendation fails to take into account federal regulations that require a defined amount of sodium be added to foods to ensure food safety (94) and that, in addition to taste, there are many uses and functions of sodium in the food supply (64) (**Table 7**). Compliance with the 2010 DG recommendations for sodium may require Americans to substantially change their eating behaviors and/or require a "profound modification of the U.S. food supply" (95). Nevertheless, the food industry and quick-serve restaurants are currently addressing sodium reduction through lower sodium cheeses and condiments, thinner hamburger buns, more controlled cooking procedures for French fries, and greater use of spices and spice blends in cooking. Despite commitment and progress by the food industry to reduce the sodium content of foods, food safety, functionality, and sensory challenges related to sodium reduction will take time to overcome. Further, the unintended consequences of decreasing dietary intake of iodized salt, which has been reported to improve cognition in mildly iodine-deficient children (96) and has helped eliminate iodine deficiency disorders in populations throughout the world (97), will need to be addressed.

Implementation of the DG must take into account that, to consumers, taste is paramount (98) and food provides nutrition only when consumed. Some might contend that food scientists are making foods too tasty. Where do food scientists draw the line on palatability when formulating a new food product? Nutritionists need to collaborate with food scientists so that when new foods are formulated, their nutritional and hedonic qualities are taken into account.

Table 7. Examples of sodium containing compounds in the food supply[1]

Compound	Functions
Sodium chloride	Salty taste, enhances taste, reduces bitterness
	Reduces microbial growth
	Promotes the development of color in cooked meat products, cereals, and breads
	Minimizes ice-crystal formation in frozen products
	Promotes firm texture and binding strength in processed meats
	Improves tenderness
	Reduces cooking loss in meats
	Strengthens gluten in bread dough for uniform texture, grain, and dough strength
Monosodium glutamate	Enhances flavor; provides umami taste
Sodium ascorbate	Provides vitamin C
Sodium benzoate, lactate and sorbate	Preserves food
	Prevents growth of yeasts and harmful bacterial
Sodium bicarbonate	Acts as a leavening agent
Sodium citrate	Regulates pH
	Aids in emulsification
	Improves rehydration
Sodium propionate	Preserves food and inhibits mold

[1] Adapted from Reference 95 with permission.

All need to realize that taste is culture (99), age (100), and context dependent and that in our diverse population, developing a food that appeals to multigenerations and multiethnicities is challenging. Finally, all need to realize that creating foods that differ in taste or color for specific targeted audiences is difficult and expensive and when companies develop healthful foods, the addition of flavor enhancers and colors often ensures that these foods will be consumed.

Another challenge to overcome when considering implementation of the DG involves the food supply—including the time that it takes to formulate new foods, the current availability of foods, and the sustainability of the food supply. Over time, newer foods and technologies have helped make a healthful and more sustainable food supply [e.g., use of the nonatherogenic fatty acid stearic acid from cocoa butter (101), healthful oils from new corn cultivars (101), and (n-3) fatty acid stearidonic acid from soybeans, which will help to reduce the harvesting of ocean fish (28,29)]. Processed foods have been formulated with attributes such as reduced fat, low calorie, reduced sodium, caffeine free, and whole grain. These foods are widely consumed (12) and are providing consumers with healthful choices in line with the DG.

We also need to examine whether and how our current agricultural system will be able to provide Americans with the fruits, vegetables, nuts, seeds, and dairy products that they need to meet dietary recommendations. Predictions based on modeling research conducted by Buzby et al. (102) indicated that to meet the 2010 DG recommendations by 2015, an additional 10.3 and 4.7 million acres of cropland would be needed to support vegetable and fruit production, respectively, and a nearly 80% increase in cows, feed grains, and grazing acreage would be needed to produce 107.7 additional pounds of fluid milk and milk products. Meeting recommendations for fish consumption would be even more challenging. Harvesting of wild fish is not sustainable (103). Even considering aquaculture, which currently provides nearly 50% of the fish consumed worldwide (104), projections indicated that for Americans to consume the recommended number of servings of low-mercury fish (e.g., salmon), global supplies would be exceeded by 50%. Finally, we must consider that agriculture and aquaculture both require a significant amount of water, and water is a limited resource.

Examination of opportunities and challenges associated with the full implementation of the DG must be borne by consumers, the food industry, and policymakers. Opportunities and challenges include improving nutrition literacy and cooking skills; creating financial incentives to purchase, prepare, and consume healthful foods; encouraging restaurants to serve smaller portions; expanding sustainable agriculture and aquaculture; and continuing to promote physical activity (105). Collaborative efforts are already under way to address some of these challenges and include the Healthy Weight Commitment Foundation (106), the Dietary Guidelines Alliance (107), and the Alliance to Feed the Future (108).

Conclusion

Important next steps to address with respect to processed foods and their consequent role in helping Americans meet dietary recommendations are described in Table 5. Our complex food system can change over time, and advances in food science and technology will continue to provide a safe, nutritious, and abundant food supply to meet current and future needs. Public health policy must balance risks (not fears) and benefits, and collaborative efforts between food science, nutrition science and behavioral economics are needed to make positive differences in our food supply and the overall health of Americans (109). Resources are available to health professionals and opinion leaders (16,93,106–108) and can be used to disseminate important messages enabling consumers to make informed marketplace choices. In this time of public health crisis, we all must respect and value disciplines, form partnerships, and work together to improve the health of current and future generations.

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AN Advances in Nutrition An International Review Journal

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